APS Injector Complex

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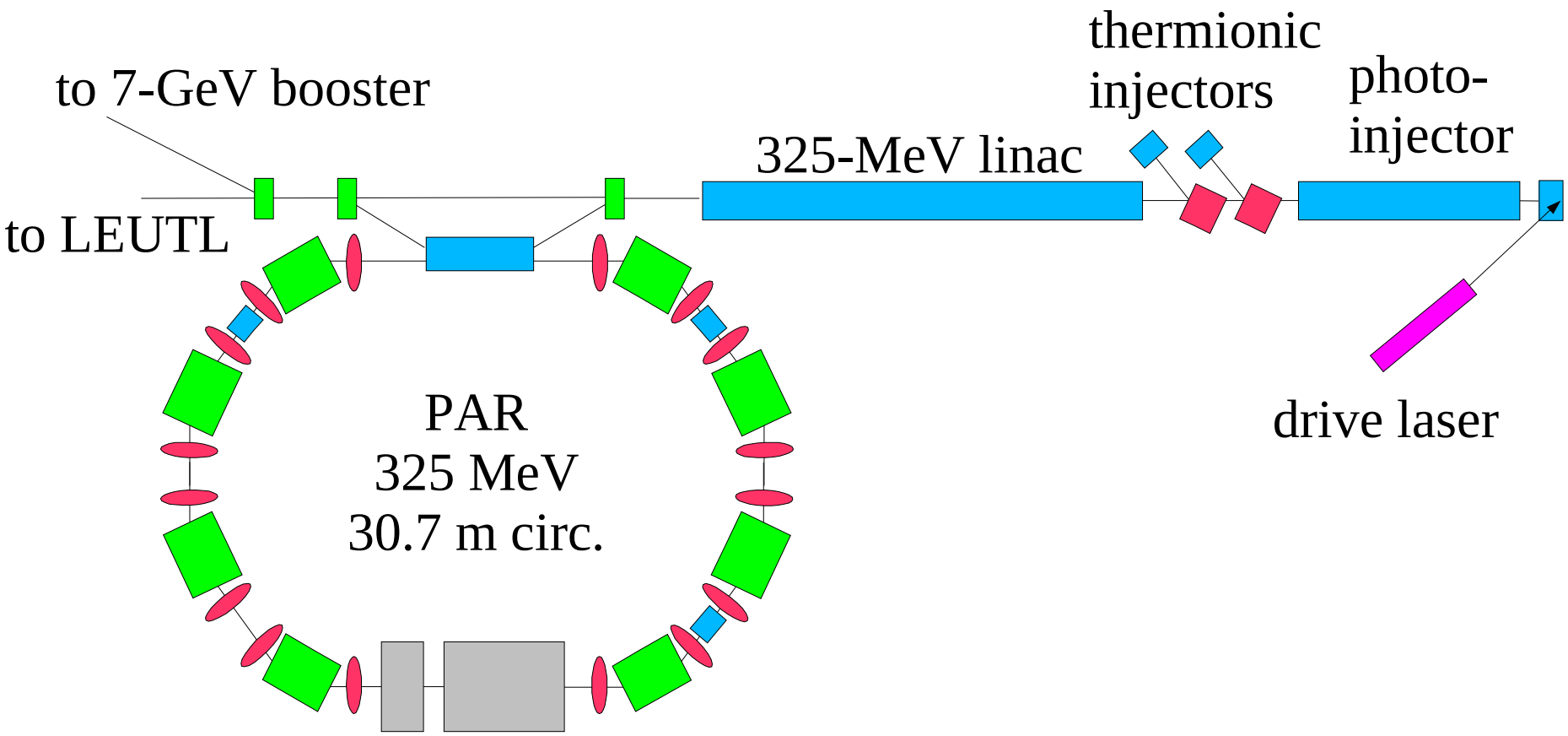
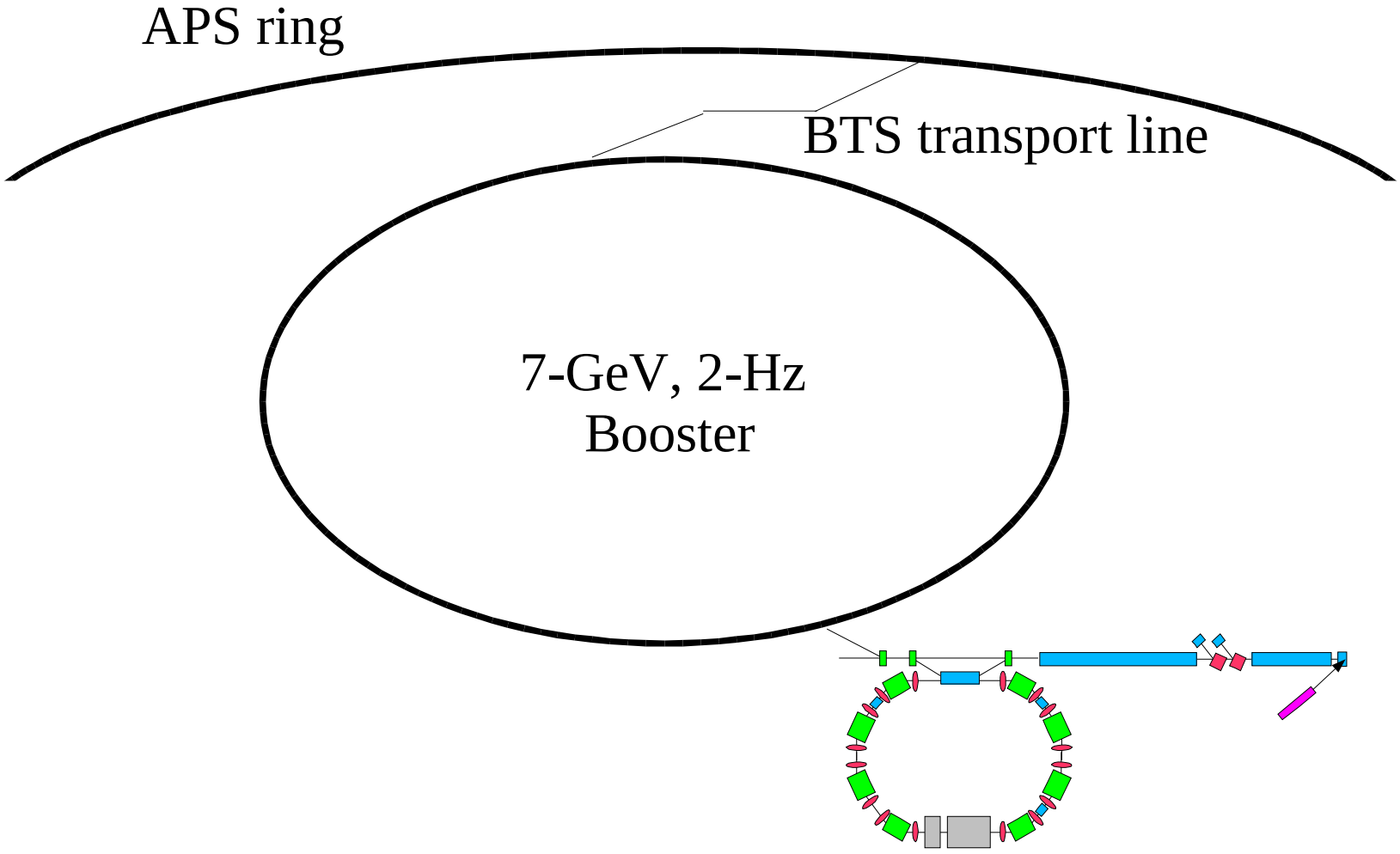
Outline

- Injector overview
- Injector requirements
- Capabilities and limitations

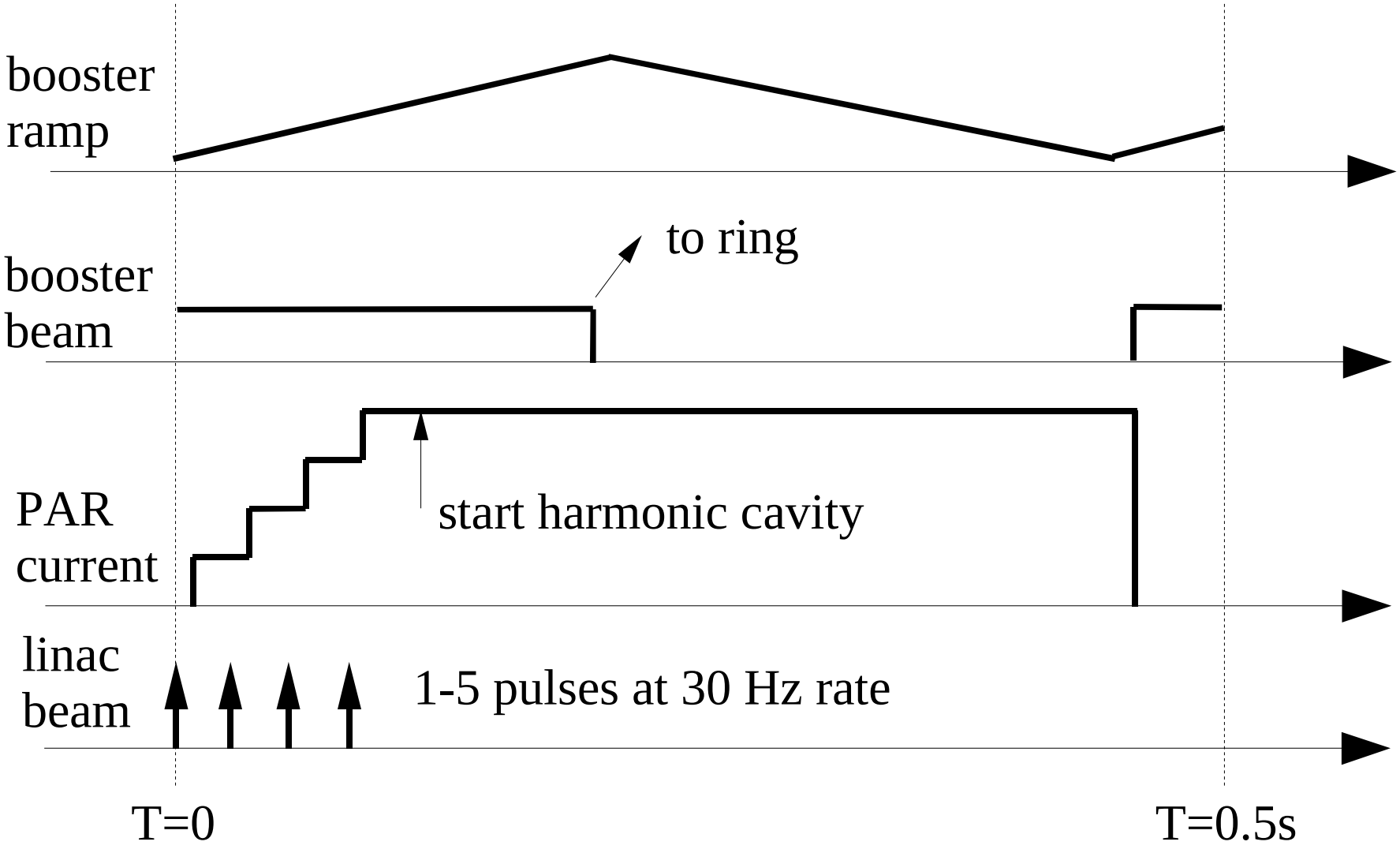
Low-Energy Injector Schematic



High-Energy Injector Diagram



Injector Timeline



General Injector Requirements

- Deliver sufficient and stable amount of charge to SR
- Maintain stable position and angle at entrance to SR
- High reliability and availability
- Ease of operation

Charge Requirements

- For top-up we are constrained by lifetime and the 2 minute interval

$$Q_{gun} = \frac{6.25\,\Delta T_{inj}}{\tau\,\eta_{inj}\,\eta_{lin}\,\eta_{PAR}\,\eta_{boo}\,N_{PAR}}$$

- Some typical numbers for low emittance lattice and using RG2 gun are

$$\Delta T_{inj} = 2\,min \qquad \tau \approx 8\,hr \qquad N_{PAR} = 4$$

$$\eta_{inj} \approx 0.65 \qquad \eta_{boo} \approx 0.9 \qquad \eta_{PAR} \approx 0.95 \qquad \eta_{lin} \approx 0.8$$

giving $Q_{gun} \approx 0.9\,nC$

Comments

- The total efficiency is about 45%
- If we go to 200mA or higher brightness configurations, the required charge increases
- At some point we have to decrease ΔT_{inj}
  - more charge needed than injector can deliver
  - too much charge per shot into one bucket
- We are close to that point now...

Injector Limitations

- RG2 can deliver ~4 nC/pulse, probably more
- BESOCM interlock set at 1 nC/pulse
  - If redesigned we could go to 4 nC/pulse and stay inside safety limits
- Booster has trouble with efficiency over ~4 nC/cycle.
- We run about 3~3.5 nC/cycle now.

Injector Alternatives

- We normally use RG2 for top-up
  - high charge, low energy spread
  - excellent PAR capture
- RG1 gun is not top-up capable due to transport line problems
- PC gun is a workable backup
  - via PAR, need 1.2 nC/shot
  - via booster, requires 2.8 nC/shot assuming 100% gun-through-booster efficiency

Upgrade Plans

- RG1 and RG2 transport lines will be redesigned to make both guns top-up capable
- A possible method for solving PC-gun-to-booster timing issues was identified and will be tested
- Exploring booster low-emittance lattice
- These changes will make our present level of operation more reliable, but won't take us to the next level...

Booster Accumulation

- Booster accumulation would allow keeping the 2 minute interval while solving all the problems
  - Modify booster power supplies to allow storing beam at injection energy
  - Accumulate beam over several PAR cycles into several buckets
  - Ramp to 7GeV and transfer all buckets together
- This will be expensive and complicated